

MAC address

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A **Media Access Control address (MAC address)** is a unique identifier assigned to network interfaces for communications on the physical network segment. MAC addresses are used for numerous network technologies and most IEEE 802 network technologies, including Ethernet. Logically, MAC addresses are used in the Media Access Control protocol sub-layer of the OSI reference model.

MAC addresses are most often assigned by the manufacturer of a network interface card (NIC) and are stored in its hardware, the card's read-only memory, or some other firmware mechanism. If assigned by the manufacturer, a MAC address usually encodes the manufacturer's registered identification number and may be referred to as the **burned-in address**. It may also be known as an **Ethernet hardware address (EHA)**, **hardware address** or **physical address**. A network node may have multiple NICs and will then have one unique MAC address per NIC.

MAC addresses are formed according to the rules of one of three numbering name spaces managed by the Institute of Electrical and Electronics Engineers (IEEE): MAC-48, EUI-48, and EUI-64. The IEEE claims trademarks on the names EUI-48 and EUI-64, in which EUI is an abbreviation for *Extended Unique Identifier*.

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Notational conventions

The standard (IEEE 802) format for printing MAC-48 addresses in human-friendly form is six groups of two hexadecimal digits, separated by hyphens (–) or colons (:), in transmission order (e.g. 01–23–45–67–89–ab or 01:23:45:67:89:ab). This form is also commonly used for EUI-64. Another convention used by networking equipment uses three groups of four hexadecimal digits separated by dots (.) (e.g. 0123.4567.89ab), again in transmission order.^[1]

Address details

The original IEEE 802 MAC address comes from the original Xerox Ethernet addressing scheme.^[2] This 48-bit address space contains potentially 2^{48} or 281,474,976,710,656 possible MAC addresses.

All three numbering systems use the same format and differ only in the length of the identifier. Addresses can either be **universally administered addresses** or **locally administered addresses**. A universally administered address is uniquely assigned to a device by its manufacturer. The first three octets (in transmission order) identify the organization that issued the identifier and are known as the Organizationally Unique Identifier (OUI).^[3] The following three (MAC-48 and EUI-48) or five (EUI-64) octets are assigned by that organization in nearly any manner they please, subject to the constraint of uniqueness. The IEEE expects the MAC-48 space to be exhausted no sooner than the year 2100;^[3] EUI-64s are not expected to run out in the foreseeable future. A locally administered address is assigned to a device by a network administrator,

overriding the burned-in address. Locally administered addresses do not contain OUIs.

Universally administered and locally administered addresses are distinguished by setting the second-least-significant bit of the most significant byte of the address. This bit is also referred to as the U/L bit, short for Universal/Local, which identifies how the address is administered. If the bit is 0, the address is universally administered. If it is 1, the address is locally administered. In the example address 06-00-00-00-00-00 the most significant byte is 06 (hex), the binary form of which is 00000110, where the second-least-significant bit is 1. Therefore, it is a locally administered address.^[4] Consequently, this bit is 0 in all OUIs.

If the least significant bit of the most significant octet of an address is set to 0 (zero), the frame is meant to reach only one receiving NIC.^[5] This type of transmission is called unicast. A unicast frame is transmitted to all nodes within the collision domain, which typically ends at the nearest network switch or router. Only the node with the matching hardware MAC address will accept the frame; network frames with non-matching MAC-addresses are ignored, unless the device is in promiscuous mode.

If the least significant bit of the most significant address octet is set to 1, the frame will still be sent only once; however, NICs will choose to accept it based on different criteria than a matching MAC address: for example, based on a configurable list of accepted multicast MAC addresses. This is called multicast addressing.

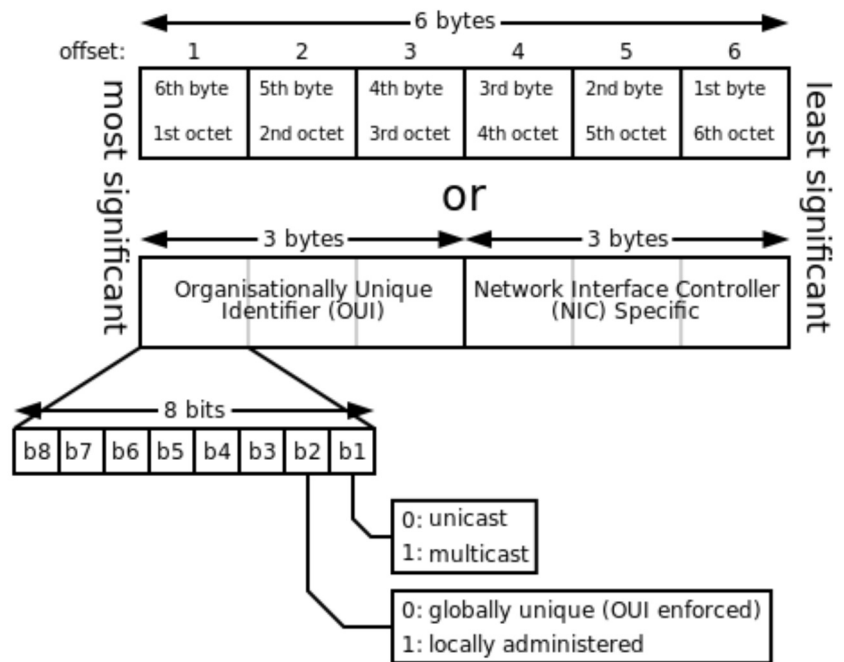
The following technologies use the MAC-48 identifier format:

- Ethernet
- 802.11 wireless networks
- Bluetooth
- IEEE 802.5 token ring
- most other IEEE 802 networks
- FDDI
- ATM (switched virtual connections only, as part of an NSAP address)
- Fibre Channel and Serial Attached SCSI (as part of a World Wide Name)
- The ITU-T G.hn standard, which provides a way to create a high-speed (up to 1 gigabit/s) local area network using existing home wiring (power lines, phone lines and coaxial cables). The G.hn Application Protocol Convergence (APC) layer accepts Ethernet frames that use the MAC-48 format and encapsulates them into G.hn Medium Access Control Service Data Units (MSDUs).

The distinction between EUI-48 and MAC-48 identifiers is purely nominal: MAC-48 is used for network hardware; EUI-48 is used to identify other devices and software. (Thus, by definition, an EUI-48 is not in fact a "MAC address", although it is syntactically indistinguishable from one and assigned from the same numbering space.)

The IEEE now considers the label MAC-48 to be an obsolete term, previously used to refer to a specific type of EUI-48 identifier used to address hardware interfaces within existing 802-based networking applications, and thus not to be used in the future. Instead, the proprietary term EUI-48 should be used for this purpose.

EUI-64 identifiers are used in:



- FireWire
- IPv6 (Modified EUI-64 as the least-significant 64 bits of a unicast network address or link-local address when stateless autoconfiguration is used)
- ZigBee / 802.15.4 / 6LoWPAN wireless personal-area networks

The IEEE has built in several special address types to allow more than one network interface card to be addressed at one time:

- Packets sent to the *broadcast address*, all one bits, are received by all stations on a local area network. In hexadecimal the broadcast address would be `FF:FF:FF:FF:FF:FF`. A broadcast frame is flooded and is forwarded to and accepted by all other nodes.
- Packets sent to a *multicast address* are received by all stations on a LAN that have been configured to receive packets sent to that address.
- **Functional addresses** identify one or more Token Ring NICs that provide a particular service, defined in IEEE 802.5.

These are all examples of *group addresses*, as opposed to *individual addresses*; the least significant bit of the first octet of a MAC address distinguishes individual addresses from group addresses. That bit is set to 0 in individual addresses and set to 1 in group addresses. Group addresses, like individual addresses, can be universally administered or locally administered.

In addition, the EUI-64 numbering system encompasses both MAC-48 and EUI-48 identifiers by a simple translation mechanism.^[6] To convert a MAC-48 into an EUI-64, copy the OUI, append the two octets `FF-FE` and then copy the organization-specified extension identifier. To convert an EUI-48 into an EUI-64, the same process is used, but the sequence inserted is `FF-FE`. In both cases, the process can be trivially reversed when necessary. Organizations issuing EUI-64s are cautioned against issuing identifiers that could be confused with these forms. The IEEE policy is to discourage new uses of 48-bit identifiers in favor of the EUI-64 system.

IPv6 — one of the most prominent standards that uses a Modified EUI-64 — treats MAC-48 as EUI-48 instead (as it is chosen from the same address pool) and toggles the U/L bit (as this makes it easier to type locally assigned IPv6 addresses based on the Modified EUI-64). This results in extending MAC addresses (such as IEEE 802 MAC address) to Modified EUI-64 using only `FF-FE` (and never `FF-FF`) and with the U/L bit inverted.^[7]

Individual address block

An Individual Address Block is a 24-bit OUI managed by the IEEE Registration Authority, followed by 12 IEEE-provided bits (identifying the organization), and 12 bits for the owner to assign to individual devices. An IAB is ideal for organizations requiring fewer than 4097 unique 48-bit numbers (EUI-48).^[8]

Usage in Hosts

Although intended to be a permanent and globally unique identification, it is possible to change the MAC address on most modern hardware. Changing MAC addresses is necessary in network virtualization. It can also be used in the process of exploiting security vulnerabilities. This is called MAC spoofing.

A host cannot determine from the MAC address of another host whether that host is on the same link (network segment) as the sending host, or on a network segment bridged to that network segment.

In TCP/IP networks, the MAC address of an interface can be queried knowing the IP address using the Address Resolution Protocol (ARP) for Internet Protocol Version 4 (IPv4) or the Neighbor Discovery Protocol (NDP) for IPv6. In this way, ARP is used to translate IPv4-addresses (OSI layer 3) into Ethernet MAC addresses (OSI layer 2). On broadcast networks, such as Ethernet, the MAC address uniquely identifies each node on that segment and allows frames to be marked for specific hosts. It thus forms the basis of most of the Link layer (OSI Layer 2) networking upon which upper layer protocols rely to produce complex, functioning networks.

Usage in Switches

Layer 2 switches use MAC addresses to restrict packet transmission to the intended recipient. However, the effect is not immediate (address learning).

Many higher-end switches currently in distribution are Layer 3 switches. Such a switch supports IP multicast and therefore uses the IP address for routing. The switch preserves the MAC address for compatibility but does not need to use it for routing.

Bit-reversed notation

The standard notation, also called canonical format, for MAC addresses is written in transmission bit order with the least significant bit transmitted first, as seen in the output of the `iproute2/ifconfig/ipconfig` command, for example.

However, since IEEE 802.3 (Ethernet) and IEEE 802.4 (Token Bus) send the bytes (octets) over the wire, left-to-right, with least significant bit in each byte first, while IEEE 802.5 (Token Ring) and IEEE 802.6 send the bytes over the wire with the most significant bit first, confusion may arise when an address in the latter scenario is represented with bits reversed from the canonical representation. For example, an address in canonical form `12-34-56-78-9A-BC` would be transmitted over the wire as bits `01001000 00101100 01101010 00011110 01011001 00111101` in the standard transmission order (least significant bit first). But for Token Ring networks, it would be transmitted as bits `00010010 00110100 01010110 01111000 10011010 10111100` in most-significant-bit first order. The latter might be incorrectly displayed as `48-2C-6A-1E-59-3D`. This is referred to as *bit-reversed order*, *non-canonical form*, *MSB format*, *IBM format*, or *Token Ring format*, as explained in RFC 2469. Canonical form is generally preferred, and used by all modern implementations.

When the first switches supporting both Token Ring and Ethernet came out, some did not distinguish between canonical form and non-canonical form and so did not reverse MAC address bits as required. This led to cases of duplicate MAC addresses in the field.^[*citation needed*]

See also

- Organizationally Unique Identifier
- Internet Protocol version 6
- Hot Standby Router Protocol or standard alternative VRRP Virtual Router Redundancy Protocol, which allows multiple routers to share one IP address and MAC address to provide router redundancy. The OpenBSD project has an open source alternative, the Common Address Redundancy Protocol (CARP). On Linux, iptables has a CLUSTERIP target.
- NSAP address, another endpoint addressing scheme.
- Sleep Proxy Service, which may 'take over' another device's MAC address during certain periods

References

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- ↑ *IEEE Std 802-2001* (http://standards.ieee.org/getieee802/download/802-2001.pdf) . The Institute of Electrical and Electronics Engineers, Inc. (IEEE). 2002-02-07. p. 19. ISBN 0-7381-2941-0. http://standards.ieee.org/getieee802/download/802-2001.pdf. Retrieved 2011-09-08. "The universal administration of LAN MAC addresses began with the Xerox Corporation administering Block Identifiers (Block IDs) for Ethernet addresses."
- ↑ ^{*a*} ^{*b*} "Guidelines for use of the 24-bit Organizationally Unique Identifiers (OUI)" (http://standards.ieee.org/develop/regauth/tut/eui.pdf) . IEEE-SA. http://standards.ieee.org/develop/regauth/tut/eui.pdf. Retrieved 2011-09-07.
- ↑ "Standard Group MAC Addresses: A Tutorial Guide" (http://standards.ieee.org/develop/regauth/tut/macgrp.pdf) . IEEE-SA. http://standards.ieee.org/develop/regauth/tut/macgrp.pdf. Retrieved 2011-09-07.
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/html/rfc5342) .

8. ^ IEEE-RA. "What is an Individual Address Block?" (<http://standards.ieee.org/faqs/OUI.html#9>) . <http://standards.ieee.org/faqs/OUI.html#9>. Retrieved 2011-09-08.

External links

- IEEE Registration Authority Tutorials (<http://standards.ieee.org/develop/regauth/tut/index.html>)
- IEEE Public OUI and Company_id Assignment lookup (<http://standards.ieee.org/develop/regauth/oui/public.html>)
- IEEE Public OUI list (<http://standards.ieee.org/develop/regauth/oui/oui.txt>)
- IEEE Public IAB list (<http://standards.ieee.org/develop/regauth/iab/iab.txt>)
- IANA Considerations and IETF Protocol Usage for IEEE 802 Parameters (<http://tools.ietf.org/html/rfc5342>)
- IANA list of Ethernet Numbers (<http://www.iana.org/assignments/ethernet-numbers>)
- Wireshark's OUI Lookup Tool (<http://www.wireshark.org/tools/oui-lookup.html>) and MAC address list (<http://anonsvn.wireshark.org/wireshark/trunk/manuf>)

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